Seeing the Wood from the Trees: A systems approach to OH&S management

David Borys

Introduction

The term "system" has found its way into the language of occupational health and safety (OH&S), particularly through the rise in popularity of OH&S management systems (OHSMS). However, the term "system" as a label is of little practical relevance unless the richness of the concept is understood. Organisations could benefit from thinking systemically whilst acting systematically. However, to think systemically, people within organisations need a shared framework or "picture" that helps organise their thinking. Systems thinking can help provide this framework and allow for the integration and interrogation of existing OH&S knowledge and accumulated wisdom. The "Systems Model of Risk Control" (SMRC) is a framework that assists organisations to become learning communities. The SMRC allows everyone in an organisation to share a common picture of how OH&S is managed and how risk is controlled. OHSMS are one component of a systems approach to risk control. Over-reliance upon OHSMS when implemented out of context may not represent the best use of resources available for risk improvement or enhance OH&S performance. The SMRC allows organisations to move beyond the "one-size fits all" approach to OH&S management and to develop and share an approach that best suits organisational needs. Individual organisational needs may or may not be best served by an OH&S management system.

Over the past decade, a range of approaches to improving occupational health and safety (OH&S) has confronted organisations. This includes cultural change, teamwork, benchmarking, integrated management systems, quality management, risk assessment, behaviour modification programs and OH&S management systems. Often, these are collectively known as best practice but which approach or combination of approaches that an organisation should select is unclear.

The use of OH&S management systems has emerged as a particularly popular approach to reducing injury and illness in the workplace.[1] A systems approach to OH&S management is currently the preferred language of OH&S professionals, OH&S researchers, governments, standards bodies and organisations. According to Hale and Hovden,[2] the use of OH&S management systems in the 1990's represents the *third age of safety*. The first age was a technical age that lasted from the start of the century to post world war two, whilst human factors and the 1980's characterised the second age.[2]

In Australia, the 1995 Industry Commission[3] inquiry and report into OH&S recognised that *best practice* organisations, measured in terms of OH&S outcomes, have enterprise *safety management systems.* The Commission recommended that OH&S legislation in each jurisdiction recognise safety management systems as a means for managing risk.[4]

Internationally, despite the International Organisation for Standardisation (ISO) decision in 1997 not to proceed with an international standard on OH&S management, there remains a strong global trend towards the development of specification and guidance standards for OH&S management systems by both government and non-government bodies.[5]

OH&S Management Systems Defined

This enthusiasm for the adoption of OH&S management systems has resulted in a plethora of propriety products becoming available to organisations. Many prospective purchasers are not only unsure of their needs but also unaware of the benefits that than an "off the shelf" system may offer. Defining 'OH&S management system' would help alleviate this uncertainty.

Waring[6] provides what he refers to as a *working definition*, that is:

> A structured systematic means for ensuring that both general and particular aspects of what the organization does are effectively managed to meet high standards of safety.

Standards Australia[7] define an OH&S management system as:

> That part of the overall management system which includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the OHS policy, and so managing the OHS risks associated with the business of the organization.

Both definitions focus upon the purpose of the system, that is, to effectively manage OH&S risks within organisations. In his definition, Waring[6] describes an OH&S management system as a *structured systematic* means for managing risk. This is construed to be similar to Standards Australia's[7] approach that describes such activities as planning, developing and implementing. It can thus be inferred that both definitions are referring to systematic approaches to risk control.

There are, however, differences between a *systematic* and *systems* approach to risk control that need to be recognised. It is possible to have a *systematic* approach without fully understanding the risk control *system*. Waring[6] argues that this *confusion between system and systematic explains why some so-called systems often fail to meet expectations* Waring[8] defines systematic as an *organized way of doing something*. OH&S management systems represent an organised way for controlling risk. OH&S management systems contain some but not all of the ingredients of a *systems* approach.[6] Such misunderstanding and confusion over the use of language may result in organisations over-looking significant opportunities for risk improvement.

To capture the significant opportunities for risk improvement that arise out of an understanding of the risk control system, those who work within organisations would benefit from having systems understandings before engaging in systematic improvement. In particular, a systems framework would enable leaders and managers to learn from system failures and organise their thinking in relation to systems approaches to managing risk.

Several writers have already identified the need for such a framework. For example, Cox and Cox[9] have argued that:

> ... for organisations to develop a vision and a strategy for managing any particular function, it must have a way of thinking about it. The organisation must a have a conceptual framework for managing that function.

Hale et al.[10] following a review of the literature on safety management systems (SMS), came to a similar view:

> ... there have been few attempts to produce coherent and comprehensive models of an SMS ... there is increasing literature in the area which is difficult to interpret and use without some framework which indicates how the results might be linked together. There is a need for a framework to represent that complexity and dynamics of management in this area.

Viner[11] provides an even deeper insight:

> ... we have no internationally recognised set of concepts (and consequently terms to use in speech) nor a uniformity of approach to the subject which assists professionals from the diverse interested fields to communicate with one another.

Therefore, a systems framework for risk control should at least meet the following criteria. It should:

- define terms;
- be both simple and comprehensive;
- be practical;
- unify existing accident causation theory and OH&S management knowledge;
- promote a shared understanding;
- promote a common language; and,
- allow for description, analysis, synthesis and improvement.

Consequently, this paper has two aims. It will:

- apply the ideas of systems thinking leading to the development of a systems framework for accident causation and risk control; and,
- unify contemporary OH&S theories within the framework.

The development of a systems framework for accident causation and risk control allows for OH&S management systems, together with the range of other approaches to OH&S, to assume the context and purpose identified as necessary for the effective, systematic control of OH&S risk.

A Review of Systems Thinking as a Framework

The term *system* has become a fashionable label in Western society to such an extent that Flood and Jackson[12] argue that it has been rendered useless. The way the term has found its way into use in popular OH&S language is evidence of this generalised labelling. Flood and Jackson[12] argued for a return to the richness of the concept *system* as a means to enhance its practical relevance. Systems thinking or treating organisms as *whole* entities, which cannot be understood from examining their parts, emerged in the 1940's in response to the failure of mechanistic or reductionist thinking. Therefore, systems thinking is a particular way of organising thoughts about the world, organisations and problems.[12] Waring[8] defines the concept of a *system* as a *recognizeable whole consisting of a number of parts [called components or elements] that are connected up in an organized way*. Senge et al.[13] illustrate the concept of a *whole* in the following way:

> ... you won't be able to "divide your elephant in half" ... you can't redesign your system (the elephant) by dividing it into parts; everyone must look at the whole together.

Checkland and Scholes[14] described the purpose of systems thinking as the construction of abstract systems models against the perceived real world, in order to learn about and improve some aspect of the real world. In this instance, the aspect of the real world to be learnt about and improved is OH&S.

Systems theory and systems thinking is, however, a labyrinth of abstract terminology, methodologies and system types. For example, Jackson[15] identifies and analyses five methodological approaches to systems thinking - organisations as systems, hard systems thinking, organisational cybernetics, soft systems thinking and critical systems thinking. Carter et al.[16] argued that a particular system may be made up of a range of system types, for example, natural systems, abstract systems, designed systems and systems of human activities. Waring,[8] drawing upon the work of Carter et al.[16] presents three types of systems thinking that are also similar to Jackson's;[15] hard systems thinking, soft systems thinking and systems failures thinking. By comparison, in a discussion of system types, Mant[17] uses a frog and a bike as metaphors to differentiate between system level (context and purpose) and component level (operations and function) solutions to problems. Mant[17] argues that:

> ... You can disassemble a bicycle completely ... and reassemble it confident that it will work as before. Frogs are different. The moment you remove any part, all the rest of the system is affected instantly ... for the worse ...

Before systems thinking can be used as an organising framework for unifying existing OH&S knowledge, it is useful to have a deeper understanding of organisations as systems. According to Jackson,[15] systems theory has competed with scientific management and human relations theory as the prominent management model within organisational theory since the 1930's.

Although the idea of organisations as systems is underpinned by a number of theoretical approaches, contingency theory and sociotechnical systems theory are discussed here as they are relevant to the use of systems thinking as an organising framework for unifying existing OH&S knowledge.

Contingency theory came into prominence in the 1970's and views organisations as *consisting of a series of interdependent subsystems, each of which has a function to perform within the context of the organization as a whole.*[15] Contingency theory assumes an open systems view. That is, the system interacts with its external environment (through a management sub-system), comprises inputs, processes and outputs (through a technical sub-system) and relies upon feedback to keep the system in a stable state.[15] Jackson[15] identified four hypotheses upon which contingency theory rests, the essence of which is that there is not one best way to manage an organisation in all circumstances.

Sociotechnical systems theory is associated with the empirical investigations in the Coal Mining Studies of the Tavistock Institute of Human Relations from the 1940's onwards. Sociotechnical systems theory argued that organisations will only achieve their purpose if the *social, technological, and economic dimensions are jointly optimized, and if they are treated as open systems and fitted into their environments*. Sociotechnical systems theory focuses upon the alignment of work groups and technology.[15]

It is possible to be lost in the labyrinth that is systems theory and systems thinking. However, Flood and Jackson[12] provide some degree of clarity when describing the general conception of a system (see figure 1) in terms of it having a boundary, an environment within which it operates, feedback loops, inputs, processes and outputs; and, comprising elements and relationships between the elements. Senge et al.[13] describe this relationship between elements in terms of links and loops:

> ... from any element in a situation ... you can trace arrows ("links") that represent influence on another element. ... links never exist in isolation. They always comprise a circle of causality, a feedback "loop" ...

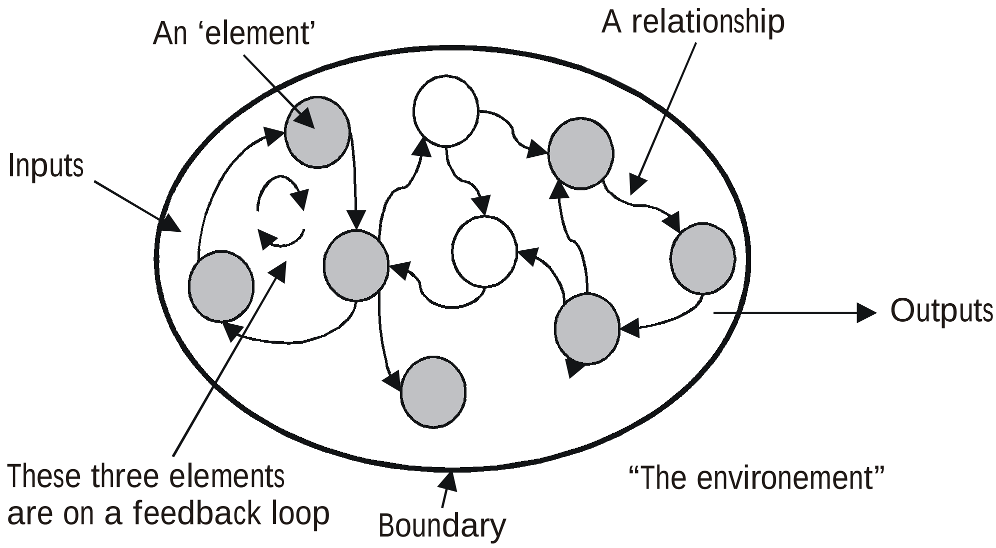


Figure 1. Flood and Jackson's General Conception of a "System"'

Together, system elements form sub-systems, which in turn form systems operating within an environment. Finally, *there is a hierarchy of possible system descriptions* ranging from broad scope and coarse resolution to limited scope and finer resolution.[16]

Systems thinking and OH&S

The application of systems thinking in relation to OH&S evolved during the 1960's when trial and error approaches were *no longer adequate for systems that had to be first-time safe*, for example aviation.[18] This led to the emergence of a new discipline - system safety - particularly within the weapons and aerospace industries, and the application of such methodological approaches to system safety as fault tree analysis. This new approach to system safety identified that risk control must be a life-cycle effort spanning the concept, design, production, operations and disposal phases of the life-cycle, with every attempt being made to design out risks in the first instance.[18]

Stephenson[18] defines a system as the *composite of people, procedures, and plant and hardware working within a given environment to perform a given task* (see figure 2). He defines system safety as the *discipline that uses systematic engineering and management techniques to aid in making systems safe throughout their life cycles.*

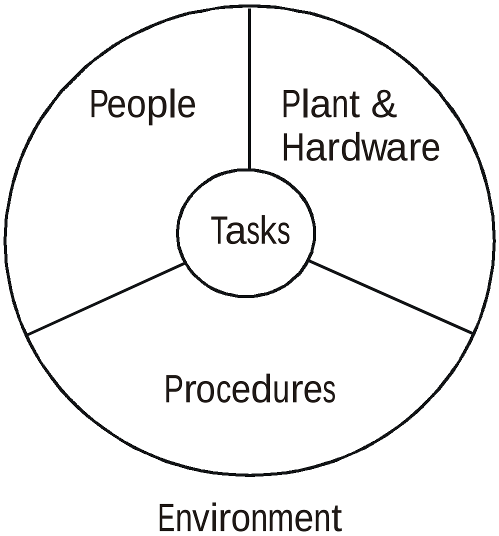


Figure 2. Stephenson's System Safety Model

In the early 1970's, Johnson and Lowman[19] applied systems concepts to OH&S when they developed the Management Oversight and Risk Tree (MORT) as part of their research conducted for the United States Atomic Energy Commission.

More recently a number of authors have called for the application of systems ideas to learning from failures and managing and improving OH&S.[9,20,21,22,23,6,7] Additionally, as previously discussed, there is a global trend towards the development of OH&S management systems.

To take a specific example, Reason[24] argued that there have been three over-lapping ages of safety. In the 1990's, OH&S moved into the third age of safety – a sociotechnical age, a move away from the technical and human error ages of previous decades. Reason's view provides an interesting counterpoint to that of Hale and Hovden[2] who argued that the 1990's, as the third age of safety, are characterised by OH&S management systems. In drawing upon systems theory Reason[25] argued that:

> Although general systems theory and the notions of sociotechnical systems theory have been with us for quite some time, decades passed before most of us began fully to realise their implications for accident prevention and safety, namely to recognise that the major residual safety problems do not

belong exclusively to either the technical or the human domains. Rather they emerge from as yet little understood interactions between technical and social aspects of the system.

Rasmussen[22] also acknowledged the relationship between sociotechnical systems theory and risk management but raised the debate to the level of a cross-disciplinary convergence of ideas at all levels of the system for a particular hazard. Rasmussen[22] argued that this requires *a system-oriented approach based on functional abstraction rather than structural decomposition*.

A Review of Key OH&S Theories

Theories of accident causation and risk control have developed in depth and scope throughout most of the twentieth century as is evidenced by the work of Viner[11], Culvenor[25] and Reason.[26,24,27,28] Over the past decade, each has contributed significantly to the understanding of the processes that lead to damage, and each have developed and published their own models for understanding risk control.

The occurrence consequence model

In 1991, Viner published *Accident Analysis and Risk Control* in which he reviewed a range of OH&S theories and models. In this work he argued strongly in favour of the application of scientific method to the study and understanding of the processes that give rise to damage and their control. He further argued that hypotheses are difficult to prove in OH&S and suggested alternative criteria.[11]

- The ability to define terms in a non-judgemental way; and,
- The utility of the concept in terms of satisfying our needs for a useful analytical tool which will stimulate research and be of value to practitioners.

Viner dispensed with the word accident. Instead he referred to the process leading to damage as the *occurrence* and the injury and ill health that results from this process the *consequence*.[11] The models he reviewed were selected on the basis of their *intrinsic or historical interest and significance*.[11] The range of models reviewed illustrates how different models suit different circumstances.

A summary and short commentary on each model is shown in table 1.

Table 1. A summary of OH&S models reviewed by Viner.

Category	Author	Model
	Heinrich (1959)	The Domino Model: Models the causes of accidents and asserts that 88% of injuries are due to *unsafe acts*, 10% to *unsafe conditions* and 2% are simply unpreventable. Eliminating unsafe acts can reduce accidents.
Cause –Effect Models	The Swedish Information System	Accidents occur as a series or sequence of events.
	Compes (1979)	A chain of multi-causal events occurring sequentially in time.
Psychological Models	Waller and Klein (1973)	The Task-Demand Model: Focus is upon the individual worker and their performance relative to the demands placed upon that performance by the task. Keeping the task within the limits of human performance can reduce accidents.
	Surry (1974)	Decision Model: Focus is upon the cognitive processes of the individual worker in their environment and their capacity to perceive, process and respond to danger.
	Corlett and Gilbank (1978)	A detailed analysis of the human as an information processor.
	Wigglesworth (1972)	Injury Causation Model: Focus is upon the individual worker and hazards. Injury occurs when errors (*a missing or inappropriate response to a stimuli*) are made in the presence of a hazard (*a source of potentially damaging energy*). Reducing errors can prevent accidents.
Energy Based Models	Gibson (1961) and Haddon (1973)	Energy Damage Concepts: Focus is upon the need for energy to be present for injury to occur. Preventing unwanted energy transfers can prevent accidents.
Uncertainty and Probability Models	Rowe (1977)	The Risk Estimation Model: Uncertainty is an inherent part of the damage process.

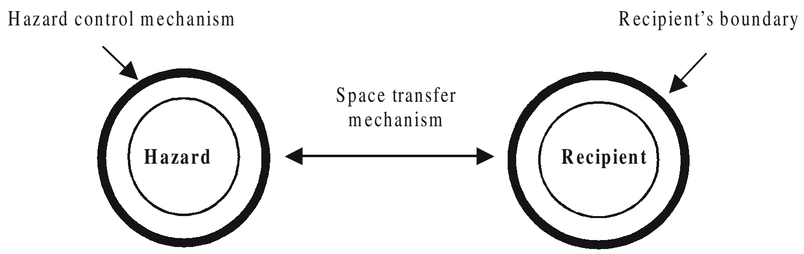
In his analysis of these models, Viner[11] concluded that there are three basic principles that arise:

1. Energy is required to produce injury and damage
2. The process develops sequentially in time

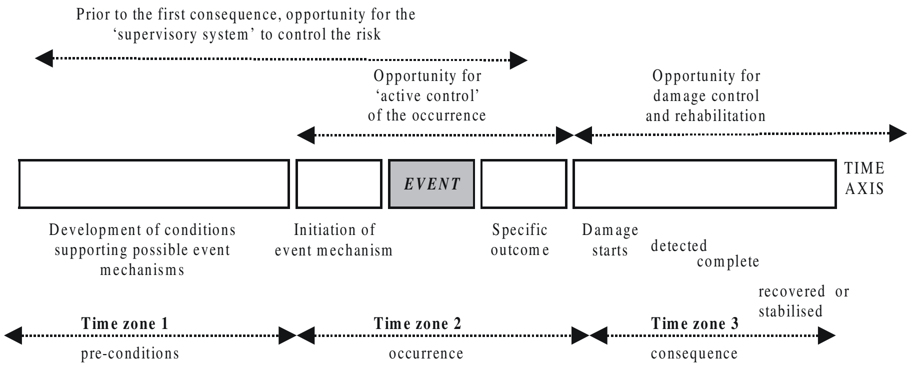
3. That the process involves uncertainty

Viner[11] used these principles as the basis for the development of three related models shown at figure 3.

The Extended Energy Damage Model



The Generalised Time Sequence Model



The Occurrence-Consequence Model

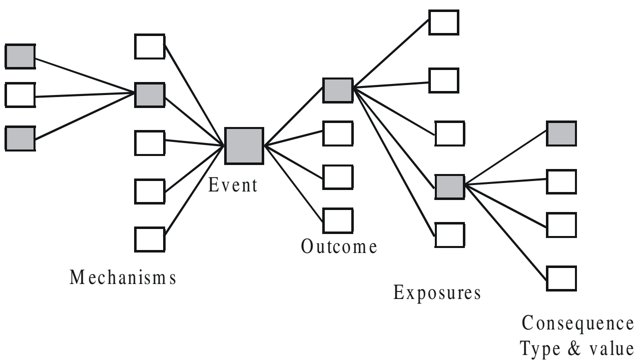


Figure 3. Viner's Models: Top – The Extended Energy Damage Model, Middle – The Generalised Time Sequence Model, Bottom – The Occurrence-Consequence Model.

Viner[11] defines the terms used in each model. For example, *hazard* is defined *as a source of potentially damaging energy* and *event* as *that point in time at which control is lost over the potentially damaging properties of the energy source*.

The ergonomic hazard management model

Culvenor[25] reviewed the history of OH&S theory. Like Viner, Culvenor reviewed the pioneering work of Heinrich and the subsequent development of the safe person versus safe place ways of thinking about safety problems and the classification of accident causes. Culvenor[25] stated that recent surveys conducted in Australia found evidence that in Australia today, *the role of unsafe behaviour remains entrenched* and that worker carelessness was the cause of accidents.

After dispensing with the role of unsafe behaviours as a case of *mistaken identity*, Culvenor turns his attention to the concept of control at source. Control at source is based upon the occupational hygiene principle of *hazard* -> *source* -> *pathway receiver*.[25] Culvenor goes on to draw upon the earlier of work of Gibson (1961), Haddon (1963) and Viner (1991) by defining the hazard source in terms of energy. At this point, Culvenor's thinking converges with Viner's in that the process leading to damage is understood in terms of the *energy source* -> *pathway* -> *receiver*.[24]

Culvenor's thinking diverges from Viner's through the application of ergonomic thinking and models as means of identifying opportunities for control. Culvenor[25] reviewed the work of Birmingham and Taylor (1961), Taylor (1957), Chapanis (1965), Kuhlmann (1986), Hammond (1978) and Grandjean (1982) and concluded that:

> ... the study of ergonomics has shown the importance of the interaction of system elements. It is not only good human skills, good equipment, and good environment conditions or systems that are important for good design, it is the quality of the interaction between these elements.

In consolidating the various approaches (see figure 4) Culvenor argues *that the classic person-equipment-environment ergonomic model can be combined with the traditional* hazard source pathway receiver model *to show more clearly the relationship of the ergonomic elements in the action of control*.[25]

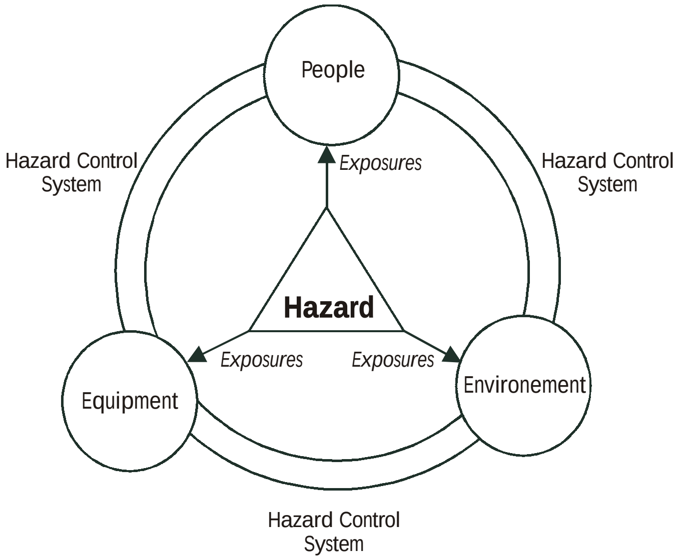


Figure 4. Culvenor's Ergonomic Hazard Management Model

The organizational accident causation model

James Reason has long been involved in research into human error. Reason[26] defined human error as a:

> ... generic term to encompass all those occasions in which a planned sequence of mental or physical activities fails to achieve its intended outcome, and when these failures cannot be attributed to the intervention of some chance agency.

Reason[26] developed a conceptual framework (*the generic error-modelling system [GEMS]*) as a means for locating the origins of various error types. According to Reason,[25] the purpose of GEMS is to integrate *slips, lapse* and *mistake* type errors into Rasmussen's *skill-rule-knowledge* classifications of human performance to arrive at three basic error types:

1. Skill-based slips (and lapses)
2. Rule-based mistakes
3. Knowledge-based mistakes

Over the past decade, Reason has shifted his focus to organisational errors. He argued that human error is *a consequence not a cause* and that human errors are *shaped and provoked by upstream workplace and organizational factors*.[28] Prevention depends upon an understanding of the organisational factors that provoked the error. These organisational factors have variously been termed *latent errors*[25], *latent failures*[24] and most recently - *latent conditions.*[28] Reason[26] defined a latent failure as:

> ... an error or violation that was committed at least one to two days before the start of the actual emergency and played a necessary (though not sufficient) role in causing the disaster.

Reason[27] described the influence of organisational factors upon human error in the following way:

> Management decisions regarding, say, training, the allocation of resources, cost-cutting, reduced manning levels, and the like can increase error likelihood in the workplace by creating error-enforcing and violation-promoting conditions at the 'sharp end' (e.g. poor provision of tools and equipment, high workloads, time pressure, inappropriate or unavailable procedures, lack of knowledge and experience, fatigue-enhancing shiftwork patterns, low morale, etc.)

Reason argued that latent conditions are spawned by those distant in space and time from the worker work interface and may lie dormant in the system for many years.

He further argued that latent conditions follow two interrelated pathways to the workplace.

1. An active failures pathway *that originates in top-level decisions* and which manifest itself in the workplace as error promoting conditions.
2. And a latent conditions pathway *that runs directly from organizational processes to deficiencies in the system's defences*.[27] These pathways are shown in figure 5.

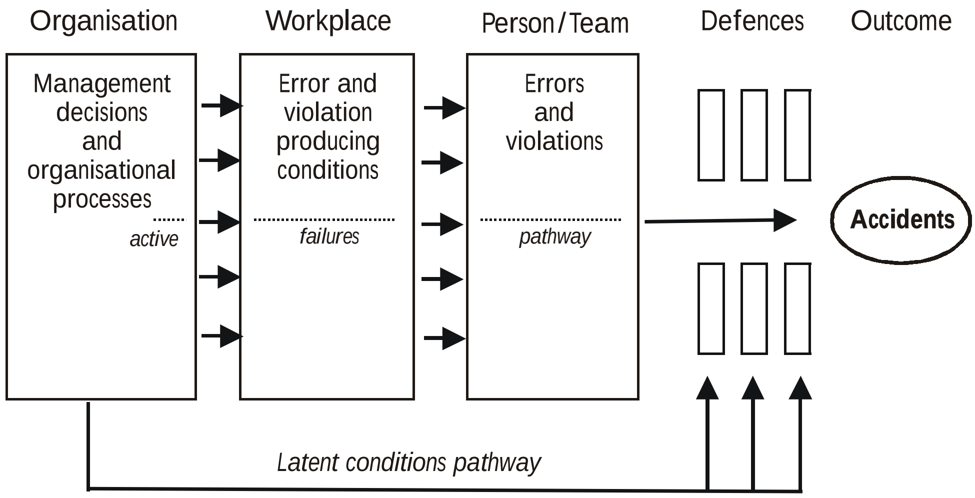


Figure 5. Reason's Model of Organizational Accident Causation

Discussion of models

Each of the contemporary thinkers discussed above has made valuable contributions from their particular perspective. Viner contributed an understanding of the role energy plays in the damage process and how this process develops sequentially over time and is inherently uncertain. Culvenor, by combining ergonomic thinking with the concept of control at source for a particular hazard. Finally Reason unravels human error and organisational error, identifying the limitations of the former in favour of the opportunities of the latter for prevention.

The differences between, and the limitations of, each model are compensated for by the synergy between the models. As an example, Viner's *development of conditions supporting possible event mechanisms* under the control of the *supervisory system* within time zone one are closely related to Reason's development of *latent conditions* at the organisational level of the system. Both Viner and Reason sequentially build up the process leading to damage. While Culvenor's model does not provide for this sense of time, if it is located within time zone one of Viner's occurrence-consequence model, then it does identify the points of intervention for risk control by the *supervisory system* at the organisational level. Both Culvenor and Reason acknowledged the limitations of focusing upon the behaviour of the individual worker at the workplace, in favour of upstream system approaches to prevention.

Models tend to stand alone reflecting the interest and discipline of the researcher. The challenge for the next generation of thinking is to achieve consilience. Wilson[29] suggests that:

> The greatest challenge today ... in all of science ... is the accurate and complete description of complex systems. Scientists have broken down many kinds of systems. They know most of the elements and forces. The next task is to reassemble them ...

The next section takes on this challenge and attempts to reassemble and unify OH&S knowledge using systems theory as an organising framework.

Systems Models of Accident Causation and Risk Control

In drawing the threads of this discussion together, the first steps towards consilience are taken using systems theory. This will supply the organising framework for the development of a new systems models of accident causation and risk control and allow for the unification of the ideas of Viner, Culvenor, Reason with systems safety / systems failure thinking.

Wilson[30] defines a model as:

> ... the explicit interpretation of one's understanding of a situation, or merely one's ideas about the situation. It can be expressed in mathematics, symbols or words, but it is essentially a description of entities and the relationships between them. It may be prescriptive or illustrative, but above all, it must be useful.

In the first instance, formal systems models of accident causation and risk control (SMAC / SMRC – hereafter referred to as "the models" and shown in figures 6 and 7 respectively) will be described. The same ideas are then simplified into a systems model of OH&S management (figure 8).

The models use a recognisable and memorable symbol[30] to represent the boundary of the risk control system - a five point star. Each point of the star represents a critical sub-system for analysing failure or understanding risk control. Polygons (pentagons) are used to illustrate the organised interconnectedness of these sub-systems consistent with systems theory.

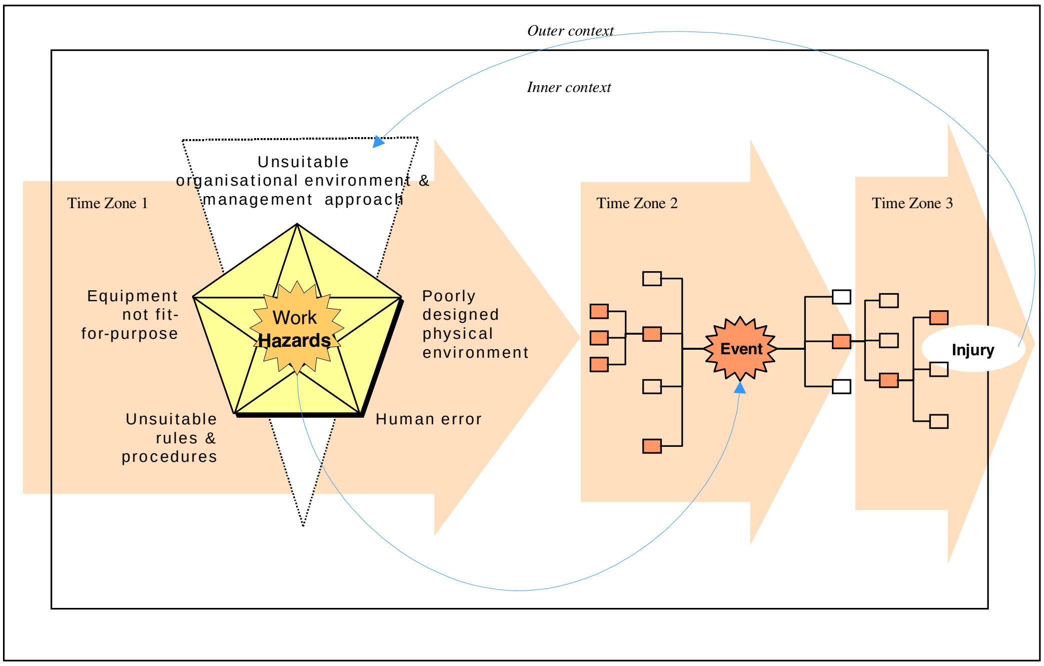


Figure 6. A Systems Model of Accident Causation

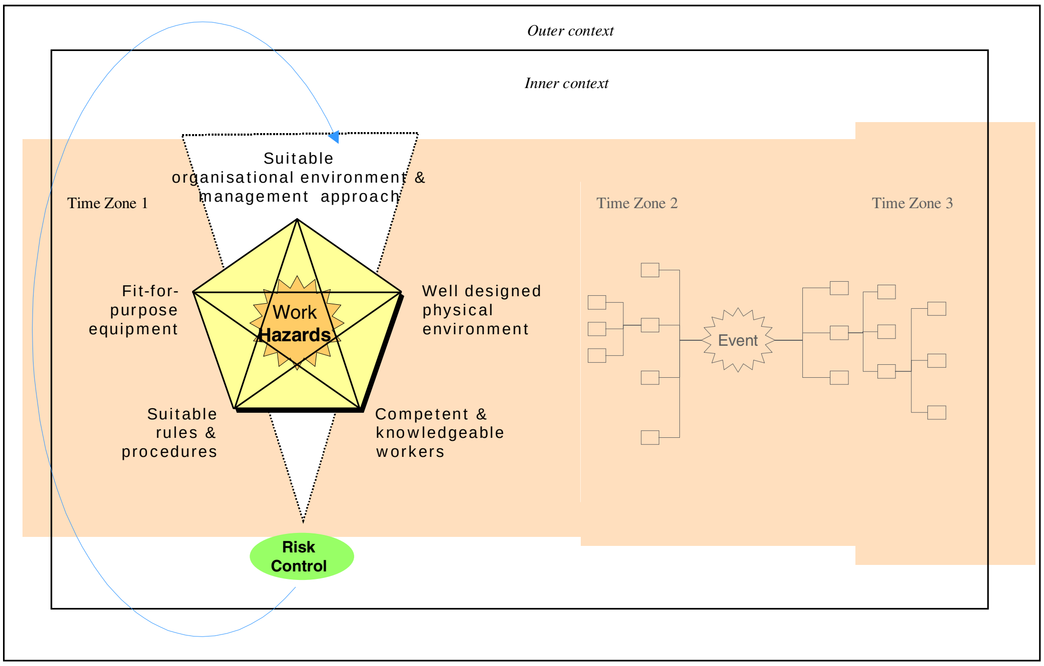


Figure 7. A Systems Model of Risk Control

At the centre of the star is work and hazards. The bottom four points of the star represent the workplace and represent a combination of Stephenson's[18] systems safety model, Culvenor's[25] ergonomic hazard management model and the ideas of sociotechnical systems theory. 'Hazard' is defined as *a source of potentially damaging energy* in accordance with Viner's models.[11] There are no limitations to what can be thought of as work. What constitutes 'work' will be defined by the practical interest of the analyst. At the coarsest level of resolution 'work' may refer to all of the operating sites of a multi-national company, conversely, at the finest level of resolution, a person typing a paper using a word processor.

The inverted triangle behind the star is an abstracted version of Reason's model. It picks up the idea that management decisions and organisational processes may lead to the development of *latent conditions* in the risk control system - the precursors of *active failures* (human error).

The inverted triangle serves three other analytical and descriptive purposes:

1. It illustrates that the points of the star are organised from the top down to form a hierarchy of risk control:
    - safe organisation (top point of the star)
    - safe place (middle two points of the star)
    - safe person (bottom two points of the star)
2. It illustrates that the area of focus for prevention is at the top of the star
3. It indicates the direction of influences in the risk control system using a vertical inputs-process-outputs concept from systems thinking. System outputs may be either risk control (the preferred system state) or an event with outcomes which may lead to injury. Both outputs feedback into the system at the organisational level and bring with them influences from the outer context.

The incorporation of Viner's generalised time sequence model adds a temporal dimension to the framework. The objective of any organisation should be to maintain the reliability of the risk control system in *time zone one* and across the *life cycle* of the business. The framework provides organisations with a picture of what lies in store if the reliability of the risk control system is not maintained – a move into *time zones two* and *three* and their associated losses. From the vantage point of time zone one, organisations are able to peer into *time zones two* and *three* through their risk analysis binoculars. What they will see is Viner's occurrence-consequence model as a structured means for analysing risk.[11]

The models are embedded within an organisational (inner) context. In turn the organisation operates in and interacts with an external environment or outer context. For example, the political, social, economic and industrial elements of the outer context are likely to influence the inner context of the organisation that in turn will influence the system for risk control.

The models also allow for deeper interrogation and analysis of any the five sub-systems whilst retaining an understanding of the whole. For example, it is possible to break the organisational environment down and speculate on its constituent elements and their relationships as well as the relationship between these elements and the role they play in influencing the level of risk in the system. According to current OH&S and management thinking these elements could include:

- Leadership, the influence of leadership on culture and the influence of culture on performance[31,28,32,6]
- The age of the organisation[28]
- The 'type' of organisation[10]

Management approaches may be broken down in a similar way – possibly into two categories: generic and OH&S specific approaches. Generic approaches could include quality management and its application to OH&S through the development of integrated management systems and the use of teamwork. Specific OH&S approaches, for example, safe behaviour programs, could be analysed in the context of the whole system and underpinned by an understanding of human and organisational error.

The benefit of the models is that it enables those who are interested in accident analysis and risk control to develop a deeper understanding and ask informed questions and make informed decisions. Organisations could use the models as frameworks against which they could evaluate their existing paradigms and mental models and select an approach or combination of approaches to risk control that best suits their needs. This approach is similar to the hypothesis underlying contingency theory that there is no one best way to structure the activities of the organisation in all circumstances - in other words "one size does not fit all", different approaches may well apply in different circumstances.

The models may be simplified to provide a memorable systems view of OH&S management (see figure 8). Such a view or picture provides context and purpose for OH&S management "systems". Organisations that operate from a shared picture or mental model of OH&S management and risk control may achieve better OH&S outcomes.

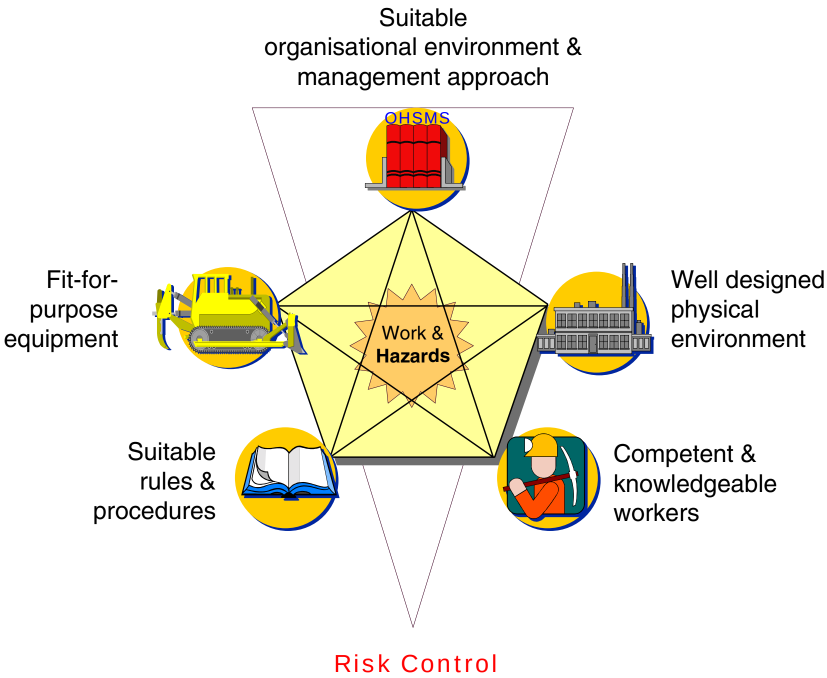


Figure 8. A Systems View of OH&S Management.

Conclusion

To date, the approach or combination of approaches that an organisation should select to improve OH&S has been unclear. Arguably, organisations must benefit from a framework that enables them to see the various approaches available, in the context of a whole. Such a framework is the systems models of accident causation and risk control. The models use systems thinking as an organising framework for unifying existing occupational health and safety knowledge. Its potential benefits will enable organisations to learn about, and organise, their risk control thinking leading to a better-informed selection of approaches to OH&S risk improvement.

References

1. Gallagher C. Health & safety management systems: An analysis of system types and effectiveness. National Key Centre in Industrial Relations, 1997.
2. Hale A, Hovden J., 1998. Management and culture: The third age of safety. In: Feyer A, Williamson A, eds. *Occupational injury: Risk, prevention and intervention*. England: Taylor & Francis, 1998.
3. Industry Commission. Work, health and safety: Inquiry into occupational health and safety, Report No. 47, Vol. 2. Canberra: Australian Government Publishing Service, 1995a.
4. Industry Commission. Work, health and safety: Inquiry into occupational health and safety, Report No. 47, Vol. 1. Canberra: Australian Government Publishing Service, 1995b.
5. Redinger C.F. & Levine S. P. Development and evaluation of the Michigan occupational health and safety management system assessment instrument: A universal OHSM performance measurement tool. *American Industrial Hygiene Journal* 1998;59(8):572-581.
6. Waring A. *Safety management systems*. London: Chapman & Hall, 1996a.
7. Standards Australia / New Zealand. Occupational health and safety management systems – General guidelines on principles, systems and supporting techniques, AS / NZS 4804:1997, Homebush: Standards Australia, Wellington: Standards New Zealand, 1997.
8. Waring A. *Practical systems thinking*. London: Thomson, 1996b.
9. Cox S. & Cox T. *Safety, systems and people*. Oxford: Butterworth-Heinemann, 1996.
10. Hale A, Heming B, Carthey J, Kirwan B. Modelling of safety management systems. *Safety Science* 1997;26(1-2):121-140.
11. Viner D. *Accident analysis and risk control*. Victoria: VRJ Delphi, 1991.
12. Flood RL, Jackson MC. *Creative problem solving*. England: Wiley, 1991.
13. Senge PM, Kleiner A, Roberts C, Ross RB, Smith BJ. *The fifth discipline fieldbook*. London: Nicholas Brealey, 1994.
14. Checkland P, Scholes J. *Soft systems methodology in action*. Wiley: England, 1990.
15. Jackson MC. *Systems methodology for the management sciences*. New York: Plenum, 1993.
16. Carter R., Martin J. & Mayblin B., Munday M. *Systems, management and change*. London: Harper & Row, 1984.
17. Mant A. *Intelligent leadership*. St Leonards: Allen & Unwin, 1997.
18. Stephenson J. *Systems safety 2000*. New York: Van Nostrand Reinhold, 1991.

19. Johnson WG, Lowman G. The management oversight & risk tree – MORT. Washington: U.S. Government Printing Office, 1973.

20. Fortune J, Peters G. *Learning from failure – The systems approach*. Chichester: Wiley, 1995.

21. Ragan P. Carder B.1994. Systems theory and safety. *Prof Safety* 1994;June:22-27.

22. Rassmussen J. Risk management in a dynamic society: A modelling problem. *Safety Science* 1997;27(2-3):183 - 213.

23. Toft B, Reynolds S. *Learning from disasters*. Oxford: Butterworth-Heinemann, 1994.

24. Reason J. 1993. Managing the management of risk: New approaches to organizational safety. In: Wilpert B, Quale T, eds. *Reliability and safety in hazardous work systems: Approaches to analysis and design*. Hove: Erlbaum Associates Ltd., 1993.

25. Culvenor J. Breaking the safety barrier. Unpublished PhD thesis. University of Ballarat, 1997.

26. Reason J. *Human error*. Cambridge: Cambridge University Press, 1990.

27. Reason J. A systems approach to organizational error. *Ergonomics* 1995;38(8):1708-1721.

28. Reason J. *Managing the risks of organizational accidents*. England: Ashgate, 1997.

29. Wilson EO. *Consilience.* Great Britain: Little, Brown & Co., 1998.

30. Wilson B. Systems: *Concepts, methodologies, and applications*. John Wiley, 1984.

31. Kotter JP, Heskett JL. *Corporate culture and performance.* New York: The Free Press, 1992.

32. Shaw A, Blewett V. Telling tales: OHS and organisational culture. *J Occup Health & Safety – Aust. & NZ* 1996;12(2):185-191.